



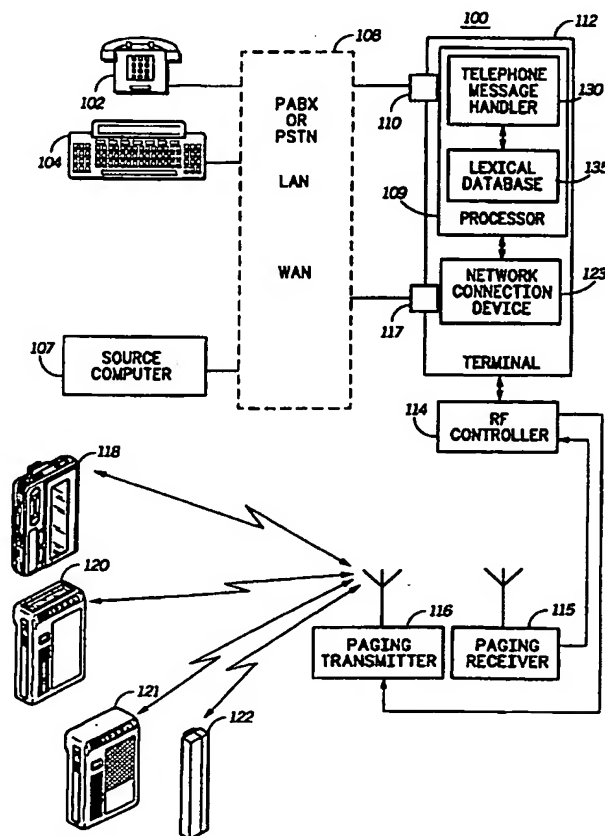
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(54) Title: ALPHANUMERIC MESSAGE COMPOSING METHOD USING TELEPHONE KEYPAD

(57) Abstract

An interactive method for composing an alphanumeric message by a caller using a telephone keypad includes storing (215) a lexical database (135) from which a plurality of words can be recovered; storing a received sequence of key codes (405) representing a sequence in which keys on a telephone style keypad are keyed; and generating a word trellis including candidate words (415) derived from the sequence and the lexical database. In one aspect of the method, a most likely phrase (420) is formed from a trellis of the candidate words using conditional probabilities stored in the lexical database. In another aspect, keypad error correction is performed when a candidate word is not found in the lexical database. In another aspect, caller responses are used to determine a correct word when all candidate words of a subset of candidate words are incorrect.



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ALPHANUMERIC MESSAGE COMPOSING METHOD USING TELEPHONE KEYPAD

FIELD OF THE INVENTION

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This invention relates in general to methods for using a telephone keypad for entering an alphanumeric message, and in particular to a method that uses one keystroke per message character.

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BACKGROUND OF THE INVENTION

The use of sophisticated personal communication devices (PCDs) such as pagers, that can display and respond to alphanumeric messages, continues to grow more and more common. Alphanumeric messages that are sent to such PCDs are generated by a machine or a person. Examples of machine generated messages are a news update and a stock market update. Messages generated by persons can be composed and sent using a computer connected to a network, or by calling a message entry service staffed by operators who enter the message, or by using a standard telephone instrument, or by using another PCD. The ability to compose alphanumeric messages by using a standard telephone instrument is highly desirable because telephone instruments are ubiquitous and familiar to most people, but adapting a telephone keypad to compose an alphanumeric message has required ingenuity because the telephone keypad was developed for numeric, not alphanumeric entry. Known techniques exist for using a standard telephone keypad for composition of alphanumeric characters. An example of a known technique involves an identification by the user of which of the three or four alphanumeric characters on one key is to be entered into the message. For example, in one method, a key is keyed one to four times within a short time to indicate which of four characters is to be entered. In another method, a key is held depressed while the characters it represents are presented to the user, one at a time (either visually or audibly), and released when the desired character is presented. While these two techniques allow an alphanumeric message to be composed successfully, they are unnatural and difficult for many callers.

Thus, what is needed is a technique for composing an alphanumeric message from a standard telephone keypad that reliable and natural.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of a messaging system, in accordance with a
5 preferred and five alternative embodiments of the present invention.

FIG. 2 shows a flow chart of a method used in a messaging terminal of the
messaging system for generating a lexical database, in accordance with the preferred and
five alternative embodiments of the present invention.

FIGs. 3 and 4 show a flow chart of a method used in the messaging terminal to
10 compose an alphanumeric message using a telephone, in accordance with the preferred and
five alternative embodiments of the present invention.

FIG. 5 shows a flow chart of a method used in the messaging terminal for generating
a word trellis, in accordance with the preferred and five alternative embodiments of the
present invention.

15 FIG. 6 shows a flow chart of a method used in the messaging terminal for performing
keypad error correction, in accordance with the preferred and five alternative embodiments of
the present invention.

FIG. 7 shows a flow chart of a method used in the messaging terminal for performing
a determination of the most likely phrase, in accordance with the preferred, first, fourth, and
20 fifth alternative embodiments of the present invention.

FIG. 8 shows a flow chart of a method used in the messaging terminal for performing
editing, in accordance with the preferred, first, second, fourth, and fifth alternative
embodiments of the present invention.

FIG. 9 shows a flow chart of a method for generating the alphanumeric message
25 from the subsets of candidate words, in accordance with the third alternative embodiment of
the present invention.

FIG. 10 is a flow chart that shows a method for performing the editing of the most
likely message in response to entries made by an operator, in accordance with the fourth
alternative embodiment of the present invention.

30 FIG. 11 is a flow chart that shows a method for performing the editing of the most
likely message, in accordance with the fifth alternative embodiment of the present invention.

Description of a Preferred Embodiment

Referring to FIG. 1, a messaging system 100, accepts page or messaging requests
5 from several external sources, e.g. a telephone 102, a page entry device 104, and a source
computer 107, in accordance with the preferred embodiment and first, second, and third
alternative embodiments of the present invention. The source computer 107 shown here is
exemplary in nature, and can function as a messaging client, a world wide web client, an
information system host, or as a world wide web host for both retrieving and serving
10 information to other clients.

A page or messaging request is normally accepted through a telephone network
input for a public or private telephone network 108 that preferably includes capabilities for
connecting to a local area network (LAN) or wide area network (WAN) for effecting high
speed network connections to devices such as the source computer 107. The public or
15 private telephone network 108 couples the page request from one of the sources (i.e., voice
message or computer message generators) to an automatic telephone input 110 or a
network input 117 at a messaging terminal 112. The public or private telephone network 108,
as well as dedicated inputs, are connected by one or more network connection devices 123
such as modems or high speed network interfaces, e.g., IEEE 802.3 or the like, supporting
20 TCP/IP or the like connections to both the Internet and intranets.

The messaging terminal 112 comprises the network connection device 123, the
automatic telephone input 110, the network input 117, and a processor 109 that comprises a
telephone message handler 130 that is coupled to a lexical database 135. The messaging
terminal 112 is preferably a conventional WMG™ Administrator! model messaging terminal
25 made by Motorola, Inc., of Schaumburg, IL. The automatic telephone input 110 provides
automatic call connection of received telephone calls in a conventional manner, and couples
digitized audio from a telephone call to the processor 109. The telephone message handler
130 comprises a time shared portion of a conventional central processing unit (CPU) and
associated processor peripherals, as a result of the CPU being operated under a set of
30 unique telephone message handling program instructions that are stored in conventional
mass memory (such as hard disk, and random access memory (RAM). The set of unique
program instructions control the operation of the processor 109 to perform the unique
functions described herein, below. It will be appreciated that, using conventional task sharing
techniques, other conventional sets of program instructions provide other functions of the
35 processor 109 that can run essentially concurrently with the telephone message handler 130.

After accepting the page request, the messaging terminal 112 routes a selective call message comprising a selective call address, and possibly a canned message, to a radio frequency (RF) controller 114 for transmission to a selective call receiver (more generically referred to as a personal messaging device). The message is configured for a protocol, such as the well known FLEX™ protocol licensed by Motorola, Inc., by the RF controller 114, which is preferably a Conductor!™ model RF controller made by Motorola and coupled to a transmitter 116, which is preferably a Symphony™ model transmitter made by Motorola, Inc. Conventional messaging systems may convey information from a caller to pager user via a plurality of message formats. Each message format can denote a mode of data (e.g., characters, numbers, audio, graphics, or "just a beep") being sent to the pager. FIG. 1 illustrates a number of personal messaging devices, alternatively called selective call receivers, subscriber units, and personal messaging units, that can receive information messages from the messaging terminal 112. The personal messaging devices illustrated are an alphanumeric messaging device 118 that is a selective call receiver that is of conventional design and has two way messaging capability, a numeric display pager 120, a voice message pager, 121 and a tone only pager 122. In the later case, the tone only pager 122 (i.e., no message is presented to the user), alerts (e.g., an audible beep), the user that a caller wants the pager user to respond by calling a prearranged telephone number, such as a receptionist telephone number. Additionally, the RF controller 114 is coupled with a conventional messaging receiver 115 that operates to receive inbound signaling information (e.g., acknowledge back responses and return channel messages) from the alphanumeric messaging device 118 and route it to the messaging terminal 112. The alphanumeric messaging device is preferably a Pagewriter™ two way pager made by Motorola, Inc. of Schaumburg, IL, which has an alphanumeric display. The messaging receiver 115 is preferably an Audience™ model receiver made by Motorola, Inc. The messaging terminal 112, the RF controller 114, the transmitter 116, and the messaging receiver 115 can alternatively be of different model and manufacture.

Referring to FIG. 2, a method for generating a lexical database is shown, in accordance with the preferred and alternative embodiments of the present invention. The lexical database 135 provides for recovery of candidate words and recovery of probabilities related to the candidate words. The lexical database 135 is generated during a setup operation of the messaging terminal 112, and is stored in a portion of a conventional mass memory. The lexical database 135 is generated by acquiring, at step 205, a large sample of word sequences of the type expected to be used in new messages; determining and storing all unigrams (single words) and probabilities for all the unigrams that are to be included in the lexical database 135 at step 210, based on probabilities of words determined from the large sample; and determining and storing in the lexical database 135 at step 215, multigrams,

which, in accordance with the preferred embodiment of the present invention, are bigrams, but which can alternatively be larger word sequences, up to a predetermined maximum length. The multigrams that are stored have probabilities determined from the sample that exceed a predetermined minimum probability. The lexical database 135 is organized in a conventional manner such that a set (or subset) of candidate words is efficiently recovered by the telephone message handler 130 when a sequence (or subsequence) of keypad codes is provided by the telephone message handler 130 to the lexical database 135. The set (or subset) of candidate words includes all the unigrams in the database that are represented by the sequence (or subsequence) of key codes. The lexical database 135 is also organized by storing the multigram word sequences and associated probabilities in a conventional manner such that a forward conditional probability for a lookup word is efficiently recovered by the telephone message handler 130 when the telephone message handler 130 provides the lookup word and preceding words (up to a predetermined maximum word sequence length) to the lexical database 135 in a request for a forward conditional probability lookup. The probability value recovered is the probability for the multigram starting with the lookup word and including as many consecutive preceding words for which a multigram match is found. The lexical database 135 is also organized such that a backward conditional probability for a word is efficiently recovered by the telephone message handler 130 when the telephone message handler 130 provides the lookup word and succeeding words (up to the predetermined maximum word sequence length) to the lexical database 135 and requests a backward conditional probability lookup. The probability value recovered is the probability for the multigram starting with the lookup word and including as many consecutive succeeding words for which a multigram match is found.

When a match is found for a key code sequence (or subsequence), a non-empty set (or subset) of candidate words is recovered. When no match is found for a key code sequence provided to the lexical database 135, a null set (or subset) of candidate words is recovered and a keypad error is assumed by the telephone message handler 130.

When no conditional probability is stored for a given lookup word and preceding words in a forward lookup, or for a given lookup word and succeeding words in a backward lookup, an unconditional unigram probability for the candidate word is recovered by the telephone message handler 130 from the lexical database 135.

In a first alternative embodiment of the present invention, the lexical database 135 stores only the unigram probabilities and one of the forward or backward conditional probabilities are stored. In a second alternative embodiment of the present invention, only the unigram probabilities are stored. In a third alternative embodiment of the present invention, the lexical database 135 stores no probabilities. Thus, in the third alternative embodiment of the present invention, when a key code sequence is presented to the lexical

database 135, a set of candidate words is returned, but no probability is provided for the candidate words.

Referring to FIGs. 3 and 4, a flow chart of a method used in the messaging terminal 112 to compose an alphanumeric message using a telephone is shown, in accordance with the preferred and first, second, and third alternative embodiments of the present invention. At step 305, a telephone call is received, and the telephone message handler 130 interacts with the caller in a conventional manner to determine to which specific personal messaging device the caller intends to direct a message. The telephone message handler 130 determines at step 310 which type of personal messaging device it is. When the personal messaging device is determined not to be an alphanumeric messaging device, at step 315, the telephone message handler 130 stops processing this method, at step 330. When the personal messaging device is determined to be an alphanumeric messaging device, at step 315, the telephone message handler 130 instructs the caller at step 320 to perform message entry using the telephone keypad in one of two modes: a digit mode and a text mode. The message entry starts in the text mode unless a predetermined key (preferably, the "0" key) is pressed first. For each alphabetic character, the caller spells out the message, using for each character of the message a key on the telephone keypad that includes the character of the message, pressing the key but once for each character of the message. The caller is also instructed to use a predetermined key, preferably the key labeled with a "#", hereinafter called the # key, as a space between each word (i.e., the # key is a delimiter for alphabetic words). To enter the text mode after the digit mode, the caller also presses the # key. To enter the digit mode, the caller keys the key labeled with a "0". Then, for each digit, the caller presses the desired digit. The end of a digit sequence (or digital "word"), is indicated by the # key code. The caller is instructed to end the message by pressing the # key twice. The predetermined keys ("0", "#") thus generate predetermined key codes that indicate word boundaries, and every word entered in the text mode starts and ends with the # key code, unless it is the first word. It will be appreciated that, in an alternative embodiment, a sequence of two, or possibly more, keys could be used in place of the single predetermined keys ("0", "#") just described. For example, in a system in which more functions are needed, a combination the # key and another key could be used. It can more generically be said that a predetermined set of key codes is to indicate word boundaries, wherein the predetermined set has length of at least one key code.

A sequence of conventional dual tone multi-frequency DTMF key codes are generated at step 325 when the caller enters the message, that are coupled to the telephone message handler 130 by the automatic telephone input 110 and are received and stored by the telephone message handler 130 at step 405. The sequence of key codes identifies the sequence in which the keys on the telephone keypad are actually keyed, and represents the

caller's desired sequence of characters (i.e., the alphanumeric message). It will be appreciated that, due to entry errors, there are occasionally extra key codes or missing key codes in any given sequence of key codes. As an example, the sentence "Can you go to IBM tomorrow morning at 10." is entered as follows (the number on the key is used to identify the key for numbered keys:

keys: 226#968#46#86#426#86667769#6676464#28#010##

CAN YOU GO TO IBM TOMORROW MORNING AT 10.

At step 410, the telephone message handler 130 determines N subsequences of the received sequence of key codes. (N is therefore an integer.) The N subsequences are subsequences of key codes separated within the received sequence of key codes by the predetermined key code for the # key. In the example given above, the N subsequences would be the key codes for keys 226, 968, 46, 86, 426, 86667769, 6676464, and 28. At step 415, the telephone message handler 130 generates a word trellis that comprises at least one subset of candidate words, which in this example would be eight subsets of candidate words (i.e., N=8).

Referring to FIG. 5, a flow chart of a method used by the telephone message handler 130 in the messaging terminal 112 for generating the word trellis of step 415 is shown, in accordance with the preferred and first, second, and third alternative embodiments of the present invention. The telephone message handler 130 generates the word trellis by presenting each of the N subsequences, one at a time at step 505, as an input to the lexical database 135. For each of the N subsequences the telephone message handler 130 determines whether a null subset is recovered at step 510. When a null subset is not recovered, the telephone message handler 130 recovers a subset of candidate words at step 515 from the lexical database 135. Recovery of a null subset indicates no candidate words match a presented key code subsequence, and the sequence is identified as an errored sequence at step 520. The telephone message handler 130 performs a keypad error correction at step 525 using the errored sequence.

Referring to FIG. 6, a flow chart of a method used by the telephone message handler 130 in the messaging terminal 112 for performing the keypad error correction at step 525 is shown, in accordance with the preferred and first, second, and third alternative embodiments of the present invention. At step 605, the errored sequence by a keypad error correction routine. At step 610, a loop procedure is set up for which each key code of the errored sequence is selected and used once. At step 615 a sub-loop procedure is set up in which a new subsequence is generated by substituting each different key code for the selected key code. At step 620, a test is done to determine whether any candidate words are recovered by

the new subsequence. When any candidate words are recovered by the new subsequence, the new subsequence is accumulated in a new subsequence memory at step 625. When no candidate words are recovered by the new subsequence, a next iteration of the sub-loop is started at step 610. When all different key codes have been substituted and tested for all key codes in the errored subsequence, then a new loop procedure is set up at step 630 for which each key code of the errored sequence is selected and used once. At step 635, a new subsequence is generated by deleting the key code selected in step 630. At step 640, a test is done to determine whether any candidate words are recovered by the new subsequence. When any candidate words are recovered by the new subsequence, the new subsequence is accumulated in the new subsequence memory at step 645. When no candidate words are recovered by the new subsequence, a next iteration of the loop is started at step 630. When each key code in the errored subsequence has been separately deleted, then a new loop procedure is set up at step 650 in which each insertion point between two consecutive key codes of the errored sequence is selected and used once. At step 655 a sub-loop procedure is set up in which a new subsequence is generated by inserting each key code at the selected insertion point. At step 660, a test is done to determine whether any candidate words are recovered by the new subsequence. When any candidate words are recovered by the new subsequence, the new subsequence is accumulated in the new subsequence memory at step 665. When no candidate words are recovered by the new subsequence, a next iteration of the sub-loop is started at step 655. When all key codes have been inserted and tested for all insertion points in the errored subsequence, then a test is performed at step 670 to determine whether any subsequences have been accumulated in the new subsequence memory.

When a determination is made that no new subsequences are in the new subsequence memory, a new loop procedure is set up at step 675 for which each insertion point of the errored sequence is selected and used once to generate two new subsequences by splitting the errored subsequence into two subsequences at each selected insertion point. At step 680, a test is done to determine whether at least one candidate word is recovered by the each of the two new subsequences. When candidate words are recovered by the new subsequences, the new subsequences are accumulated in the new subsequence memory at step 685. When candidate words are not recovered by both of the new subsequences at step 685, a next iteration of the loop is performed starting at step 675. When all iterations of step 675 are completed, a test is performed at step 676 to determine whether any subsequences were accumulated at step 685. When no subsequences are determined to have been accumulated, a spelling edit procedure (described more fully below) is performed at step 677. When any subsequences are determined to have been accumulated in the new subsequence memory at step 676 or step 670, then a new loop procedure is started at step

690 in which each new subsequence (or set of two new subsequences, in the case that step 685 is performed) that has accumulated in the new subsequence memory is used once. For each new subsequence (or set of two new subsequences), a highest unigram probability of the unigram probabilities of all candidate words that match the new subsequence (or set of two new subsequences) is determined at step 695. This is the new subsequence score. This is repeated for each new subsequence (or set of two new subsequences). At step 696, the new subsequence (or set of two new subsequences) having the highest subsequence score is selected and substituted for the errored subsequence. It will be appreciated that, following keypad error correction at step 525, the number of subsequences will in some cases be increased due to the sequence splitting at step 675. The number of subsequences is therefore identified as Q after step 525, wherein $Q \geq N$.

Referring again to FIG. 4, when the word trellis has been generated at step 415, then in accordance with the preferred, first and second alternative embodiments of the present invention, a determination is made at step 420 of a most likely phrase having a maximum combined probability. In accordance with the third alternative embodiment of the present invention, when the word trellis has been generated at step 415, the method continues as described with reference to FIG. 9, below. In accordance with the preferred and first alternative embodiments, the maximum combined probability is determined as described below with reference to FIG. 7 from those probabilities of the unigram probabilities, forward conditional probabilities, and backward conditional probabilities that are stored in the lexical database 135. The most likely phrase consists of a combination of one candidate word from each subset of candidate words. In accordance with the second alternative embodiment of the present invention, the most likely phrase is determined at step 420 to consist simply of a combination of a most probable candidate word from each subset of candidate words, wherein the most probable candidate word is the one within a subset of candidate words having a maximum unigram probability; steps 705-730 of FIG. 7 are not relevant to this aspect of the present invention.

Referring to FIG. 7, a flow chart of a method used by the telephone message handler 130 in the messaging terminal 112 for performing the determination of the most likely phrase at step 420 is shown, in accordance with the preferred and first alternative embodiments of the present invention. At step 705, a double iteration loop is set up in which partial forward probabilities, $\alpha_{i,j}$, are calculated recursively for $i = 1, 2, \dots, Q$ in a first iteration, and for $j = 1, 2, \dots, M_i$ in a second iteration which is a subiteration to the first iteration. M_i is an integer that is the number of candidate words in an i th subset of candidate words. For each value of i and j , a partial forward probability, $\alpha_{i,j}$, is calculated, as

$$\alpha_{i,j} = \max(\alpha_{i-1,k} P(w_{i,j} | W_{i-1}^0, W_{1-2}^0, \dots, W_1^0)) \text{ for } 1 \leq k \leq M_{i-1}.$$

In this formula, the expression $w_{i,j}|W_{i-1}^0, W_{1-2}^0, \dots, W_1^0$ indicates the forward conditional probability of the candidate word, $w_{i,j}$, for which the partial probability, $\alpha_{i,j}$, is being calculated, given a set of probable words $W_{i-1}^0, W_{1-2}^0, \dots, W_1^0$ that are associated with the $\alpha_{i-1,k}$ that is being used to calculate the $\alpha_{i,j}$. The forward conditional probability of the candidate word, $w_{i,j}$ is obtained by the telephone message handler 130 making a request to the lexical database 135, providing the candidate word, $w_{i,j}$ and the set of probable words that are associated with the $\alpha_{i-1,k}$, as the lookup word and preceding words, as described herein above with reference to FIG. 2.

When the partial forward probability, $\alpha_{i,j}$, has been determined by selecting the maximum value of the M_{i-1} products (of the preceding partial forward products and the associated forward conditional probabilities), a set of probable words is associated with the partial forward probability, $\alpha_{i,j}$, by adding the candidate word to a set of probable words associated with the $\alpha_{i-1,j}$ that produces $\alpha_{i,j}$, and associating the new set of probable words with $\alpha_{i,j}$.

When all of the partial forward probabilities have been calculated at steps 710 and 715, then a new double iteration loop is set up at step 720 in which partial combination probabilities, $\beta_{i,j}$, are calculated recursively for $i = Q, Q-1, \dots, 1$ in a first iteration, and for $j = 1, 2, \dots, M_i$ in a second iteration which is a subiteration to the first iteration. For each value of i and j , a partial combination probability, $\beta_{i,j}$, is calculated, as

$$\beta_{i,j} = \max(\alpha_{i,j}\beta_{i+1,k}P(w_{i,j}|W_{i+1}^0, W_{1+2}^0, \dots, W_Q^0)) \text{ for } 1 \leq k \leq M_{i+1}.$$

In this formula, the expression $w_{i,j}|W_{i+1}^0, W_{1+2}^0, \dots, W_Q^0$ indicates the backward conditional probability of the candidate word, $w_{i,j}$, for which the partial probability, $\beta_{i,j}$, is being calculated, given a set of probable words $W_{i+1}^0, W_{1+2}^0, \dots, W_Q^0$ that are associated with the $\beta_{i+1,k}$ that is being used to calculate the $\beta_{i,j}$. The backward conditional probability of the candidate word, $w_{i,j}$ is obtained by the telephone message handler 130 making a request to the lexical database 135, providing the candidate word, $w_{i,j}$ and the set of probable words that are associated with the $\beta_{i+1,k}$, as the lookup word and succeeding words, as described herein above with reference to FIG. 2.

When the partial combined probability, $\beta_{i,j}$, has been determined by selecting the maximum value of the M_{i+1} products (of the associated partial forward probability, the preceding partial combined products and the associated backward conditional probabilities), a new set of probable words is associated with the partial combined probability, $\beta_{i,j}$, by adding the candidate word to the set of probable words associated with the $\beta_{i+1,j}$ that produces $\beta_{i,j}$, and associating the new set of probable words with $\beta_{i,j}$.

When all of the partial combined probabilities have been calculated at steps 725 and 730, then the most likely phrase is selected at step 735 by finding the set of probable words associated with a maximum combined probability, $\max(\beta_{1,j})$ for $1 \leq j \leq M_1$.

It will be appreciated that the above recursive calculations could be done by other methods that are essentially similar and which would yield approximately the same, as will be obvious to those of ordinary skill in the art. For example, partial backward probabilities instead of partial forward probabilities could be calculated in steps 705-715, with obvious changes being made to the formulas shown herein at steps 705-730.

In accordance with the first alternative embodiment of the present invention, one of the forward or backward conditional probabilities are not included in the lexical database 135. In this aspect of the present invention, either the steps 705-715 or the steps 720-730 are deleted as determined by the conditional probability that is not used.

Referring again to FIG. 4, a most likely message is generated and presented to the caller at step 425 in accordance with the preferred, first, and second alternative embodiments of the present invention. The most likely message is preferably generated by recombining the most likely phrase with the digits that were entered by the caller in the digit mode, during step 405. The most likely message is presented to the caller using conventional computer synthesis of the words and digits. When the most likely message has been presented to the caller, a confirming of the alphanumeric message from the most likely message is then performed at step 430. A confirmation occurs when the caller responds to the presentation with an affirmative indication at step 430, and results in a completion of the composition of the alphanumeric message at step 435, using the most likely message, which is then sent to the desired alphanumeric messaging device. A non-confirmation occurs at step 430 when the caller responds to the presentation with a dis-affirmative indication at step 430, and results in an editing of the most likely message, at step 440.

Referring to FIG. 8, a flow chart of a method used by the telephone message handler 130 in the messaging terminal 112 for performing the editing of step 440 is shown, in accordance with the preferred, first and second alternative embodiments of the present invention. By responses from the caller, an incorrect most likely message is identified by the caller at step 805, resulting in the presentation of a next most likely message. At step 810, up to R next most likely messages are presented one at a time to the caller in accordance with the preferred and first alternative embodiments of the present invention. The R next most likely messages are selected as the sets of probable words associated with the partial combined probabilities, $\beta_{1,k}$ for $1 \leq k \leq M_1$, wherein the $\beta_{1,k}$ are the $\beta_{1,k}$ as determined above when steps 725 and 730 have been completed, sorted in descending order of value, to which the digits and letters have been recombined (as in step 425). (In accordance with the first alternative embodiment, when only forward conditional probabilities are used, then substitute α for β and steps 710 and 715 for steps 725 and 730 in the previous sentence.) In accordance with the preferred and first alternative embodiments of the present invention, R is one, but can alternatively be larger. When the caller selects one of the next most likely

phrases at step **815**, it is sent to the desired alphanumeric messaging device at step **820**. When the caller identifies none of the next most likely messages as the alphanumeric messages at step **815**, then the most likely message is again presented to the caller who can select one of the candidate words for editing at step **825**. When the caller selects one of the candidate words, the telephone message handler **130** recovers from the lexical database **135** the other candidate words corresponding to the subsequence from which the selected candidate word was determined, and presents them to the caller in order of their unigram probability at step **830**. When the caller selects one of them at **835**, the selected word is used in place of the candidate word in the most likely phrase, at step **840**. When the caller selects none of the candidate words as the correct word at step **835**, then the telephone message handler **130** presents all letters represented by each key code in the subsequence, one letter at a time at step **845**, and the caller confirms the correct letter corresponding to each key code, thereby generating an edited word that is used in the most likely phrase at step **850**. For example, when the caller has pressed the keys identified by the numbers 3,6,7, the messaging terminal **112** responds with audio message that says "Please press the pound key when the correct letter is stated. "D" "E" "F" "M" "N" "O" "P" "R" "S". When more than one candidate word is wrong, steps **825** to **850** are repeated as necessary to correct all candidate words. The digits and letters are then recombined with the most likely phrase finally generated at one of steps **820**, **840** and **850** to generate the most likely message.

Steps **845** and **850** are also used, independently of the above method described that includes steps **805** to **850**, as a method for performing step **677** described above with reference to FIG. 6.

In accordance with the second alternative embodiment of the present invention, when the most likely message is non-confirmed at step **430**, then no next likely phrases are presented to the caller as described above with reference to steps **805-820**, and a determination is made at step **825** (FIG. 8) of an incorrect candidate word. The method then continues as described above with reference to steps **830-850**. Additional incorrect candidate words are determined, as necessary, and steps **830-850** are repeated for them.

Referring to FIG. 9, a flow chart shows a method for generating the alphanumeric message from the subsets of candidate words, in accordance with the third alternative embodiment of the present invention. When the word trellis has been generated at step **415** (FIG. 4), then in accordance with the third alternative embodiment of the present invention, all candidate words in all subsets of candidate words are presented to the caller at step **905**, in which all candidate words are presented one candidate word at time from each subset of candidate words to the caller, in order of receipt of the subsequences. The digits that were entered by the caller in the digit mode, during step **405**, are inserted between the subsets of candidate words in their original positions and also presented to the caller. The candidate

words and digits are presented to the caller using conventional computer synthesis of the words and digits. At step 910, a candidate word is confirmed for a first subset of candidate words, or the first subset is non-confirmed, by one or more caller responses (verbal or keypad entries) during the step of presenting all candidate words. In response to a non-confirmation at step 910, all letters represented by all key codes in a subsequence of the received sequence of key codes are presented at step 915. The subsequence corresponds to the first subset of candidate words. All letters are presented one letter at time to the caller. A confirmed letter is determined for each key code at step 920 by one or more caller responses during the step of presenting all letters. When all letters for a subsequence are confirmed, a word has been spelled. When all candidate words for all subsets of candidate words have been either confirmed or spelled, the alphanumeric message has been generated.

Referring to FIG. 10, a flow chart shows a method for performing the editing of the most likely message in response to entries made by an operator, in accordance with the fourth alternative embodiment of the present invention. The operator is a person who monitors and assists callers and communicates with the messaging terminal 112 by means of an alphanumeric keyboard and display, and a speaker and a microphone. The speaker and microphone are preferably part of a telephone headset or handset. At step 1005, when a message non-conformation is determined at step 430 (FIG. 4), or when no candidate word (a null subset) is found for a subsequence at step 510 (FIG. 5), one or more incorrect candidate words of the most likely message are determined in a conventional manner, as, for example, by presenting a voice synthesized message to the caller to activate one or two keys on the telephone keypad that indicate a position of each of the one or more incorrect candidate words within the alphanumeric message, or by asking the caller to speak a position number for each incorrect candidate word, and using a small voice recognizer within the messaging terminal 112 that is based on non-speaker dependent recognition of only such numbers. All the remaining candidate words, which can be as few as zero, are confirmed candidate words. At step 1010, a request is presented to the caller for the caller to vocalize spoken words of the alphanumeric message that correspond to each of the one or more incorrect candidate words determined at step 1005. The spoken words are recorded at step 1015, for example as digitized audio in a random access memory (RAM) of the messaging terminal 112. At step 1020, candidate words of the alphanumeric message that were confirmed at the step of determining 1005 and the spoken word recorded in the step of recording 1015 are presented to the operator. The presentation of the confirmed words to the operator is preferably done on an alphanumeric display, while the spoken words are presented to the operator by replaying the recording to essentially reproduce the caller's voice. In a first variation of the fourth alternative embodiment, entries to the messaging terminal 112 are made by the

operator, after the candidate words and the spoken words are presented to the operator at step 1020.

When the operator has a high degree of confidence in having determined the spoken word, the operator makes the entries, which are used to generate an operator-edited version of the alphanumeric message at step 1025. It will be appreciated that the operator has an advantage (in comparison to the messaging terminal 112) of making a speedy, context driven interpretation of the spoken word. The entries are preferably keyboard entries, but could alternatively be voice recognition of a word spoken by the operator, or a series of letters spoken by the operator to convey the spoken word, it being appreciated that a speaker dependent voice recognition system trained to the operator will typically be quite reliable and fast in this situation. The process then continues with the caller confirming or non-confirming the message at step 430

In a second variation of the fourth alternative embodiment, after the presentation to the operator of the confirmed candidate words and the spoken words at step 1020, the messaging terminal 112 automatically establishes a voice link at step 1030 between the caller and the operator. Step 1030 is performed in lieu of step 1025. The operator then communicates directly with the caller, at step 1035, to establish the correct words for the incorrect candidate words identified at steps 430 (FIG. 4) or 510 (FIG. 5). An operator edited version of the alphanumeric message is generated at step 1040 by the messaging terminal 112, in response to entries made by the operator after establishing a voice link at step 1030 and communicating with the caller at step 1035. As above, the operator entries are either keyboard entries or voice recognition entries.

In a third variation of the fourth alternative embodiment, step 1030 is initiated manually by an operator command to the messaging terminal 112, instead of being automatically initiated by the messaging terminal. The operator typically initiates the command when the operator does not have confidence in the spoken word presented at step 1020. Steps 1035 and 1040 follow step 1030 as described above with reference to the second alternative of the fourth embodiment.

It will be appreciated that a use of the first, second, or third alternative of the fourth embodiment of the present invention provides correction of a non-confirmed message in a natural manner, without burdening the caller with re-keying anything on the telephone keypad.

Referring to FIG. 11, a flow chart shows a method for performing the editing of the most likely message, in accordance with the fifth alternative embodiment of the present invention. At step 1105, when a message non-conformation is determined at step 430 (FIG. 4), or when no candidate word (a null subset) is found for a subsequence at step 510 (FIG. 5), or at other appropriate times, the messaging terminal 112 prompts the caller at step 1105,

using a voice synthesized prompt, to speak an edit command. At step 1110, the messaging terminal 112 recognizes the spoken edit command as one of a predetermined set of edit commands stored in the messaging terminal 112. The messaging terminal 112 uses a speaker independent voice recognition system that is a conventional small voice recognizer that is based on the predetermined set of edit commands. The edit command is recognized as a message edit command, a word edit command, or a spelling edit command. The message edit command comprises a small subset of commands such as Add Another Message; Done; Send; Insert, Delete, Change, Go Forward # Words, Go Back # Words, and Play Message. When the edit command is recognized as the message edit command at step 1110, the messaging terminal 112 executes the command at step 1115. When the edit command is recognized as the word edit command at step 1110, the editing is performed as governed by a subsequence of the sequence of keycodes that have been previously identified by the caller or the messaging terminal 112. For example, at step 1110, when recognizing the word edit command, the identification can be in response to the caller's spoken words "edit word three." In response to these spoken words, the messaging terminal 112 identifies the subsequence of the sequence of keycodes that are associated with the third word of the message. In another example, the messaging terminal 112 can identify a subsequence of the sequence of keycodes at step 510 when no subset is found to match the subsequence. (e.g., word three). The messaging terminal 112 then prompts the caller for a vocalized word at step 1120 and records the vocalized word at step 1125. The messaging terminal 112 performs voice recognition at step 1130 using a small word recognizer that matches the recorded vocalized word to each of the subset of candidate words that correspond to the identified subsequence, to find one candidate word that matches. It will be appreciated that by matching the vocalized word to the candidate word of the subset of candidate words corresponding to the identified subsequence, the word recognizer can perform a highly accurate matching in a speaker independent manner because the previously identified subsequence of keycodes reduces the size of the set of possible words to only the candidate words.

When the edit command is recognized as the spelling edit command at step 1110, the editing is performed as governed by a subsequence of the sequence of keycodes that have been previously identified by the caller or messaging terminal. For example, at step 1110, when recognizing the spelling edit command, the identification can be in response to the caller's spoken words "spell word three." In response to these spoken words, the messaging terminal 112 identifies the subsequence of the sequence of keycodes that are associated with a third word. The messaging terminal 112 then prompts the caller for a sequence of vocalized letters at step 1135 and records the sequence of vocalized letters at step 1140. The messaging terminal 112 records each letter as it is vocalized. The messaging terminal

112 performs voice recognition of each of the letters at step 1145 using a small alphabet recognizer that matches the recorded letter to the letters corresponding to a next keycode in the identified subsequence. The messaging terminal 112 begins step 1145 as soon as the first vocalized letter is recorded, to speed up the process. It will be appreciated that by
5 matching the vocalized letters to the identified subsequence, the alphabet recognizer can perform a highly accurate matching in a speaker independent manner because the previously identified subsequence of keycodes reduces the size of the set of possible letters that are compared to the recorded vocalized letter from an entire alphabet to only the number of letters corresponding to one of the keycodes during each match.

10 The spelling edit command is alternatively invoked automatically when, at step 1130, voice recognition fails to identify any candidate word of the subset of candidate words as the spoken word with sufficient reliability. In this instance, steps 1135-1145 are performed as described above, in response to step 1130

It will be appreciated that when the edit word command or edit spelling commands are
15 performed, the voice recognition performed therein is uniquely governed by a subsequence of the sequence of key codes entered by the caller using the telephone keypad. In the case of the word edit command, the governing by the subsequence is by way of the candidate words determined from the subsequence. In the case of the spelling edit command, the governing by the subsequence is by way of the letters determined from the keycodes of the
20 subsequence.

It will be appreciated that while the interactive method for composing an alphanumeric message using a telephone, in accordance with the preferred embodiment of the present invention, uses a standard telephone keypad that is found in most telephones in the USA, the invention can be readily used in accordance with alternative embodiments. For example, the
25 keypad could be directly connected to a processor by parallel signals, in a conventional fashion often used in portable telephones. In such an embodiment, a sequence of keycodes is generated that corresponds to the sequence in which the keys on the keypad are keyed, but the key codes are parallel binary codes instead of DTMF codes. Also, the keypad need not be a standard USA telephone keypad but could be a keypad having extra keys or
30 characters of other languages. When the keypad includes keys each of which represents more than one alphanumeric character, the benefits of the present invention would be achieved. Such a keypad is identified herein as a telephone style keypad, for simplicity. When another language is used, the lexical database is changed accordingly.

It will be appreciated that the operation of storing the entire key code sequence for the desired alphanumeric message in the manner described herein above with reference to FIGs. 3 and 4 allows a determination of a most likely phrase using both forward and
5 backward conditional probabilities in a unique manner that provides better results than prior art real time decoding devices, such as voice recognition. It will be further appreciated that a unique set of message correction techniques have been described that provide efficient and natural voice editing of messages to generate the alphanumeric message the caller is composing.

CLAIMS

1. An interactive method for composing an alphanumeric message by a caller using a
5 telephone keypad, comprising in a messaging terminal the steps of:
storing a lexical database from which unigram probabilities, forward conditional
probabilities, and backward conditional probabilities for a plurality of words can be recovered;
storing a received sequence of key codes that identifies a sequence in which keys on
a telephone style keypad are pressed in order to enter the alphanumeric message;
10 generating a word trellis from the sequence of key codes, the word trellis comprising
at least one subset of candidate words recovered from the lexical database;
determining a most likely phrase having a maximum combined probability
determined from the unigram probabilities, forward conditional probabilities, and backward
conditional probabilities stored in the lexical database, that consists of a combination of one
15 candidate word from each of the at least one subset of candidate words;
generating a most likely message from the most likely phrase and presenting the
most likely message to the caller; and
confirming that the most likely message is the alphanumeric message.
- 20 2. The method according to claim 1, wherein the step of generating a word trellis from the
sequence of key codes comprises the steps of:
determining N subsequences of the received sequence of key codes,
wherein the N subsequences are subsequences of key codes separated within the received
sequence of key codes by a predetermined set of key codes; and
25 recovering the at least one subset of candidate words from the lexical database
based on an input to the lexical database of one of the N subsequences.
3. The method according to claim 2, wherein the predetermined set of key codes comprises
a code that represents a key labeled #.

30

4. The method according to claim 1, wherein in the step of determining a most likely phrase, the maximum combined probability is determined by the recursive steps of:

calculating $\alpha_{i,j}$ as $\alpha_{i,j} = \max(\alpha_{i-1,k} P(w_{i,j} | W_{i-1}^0, W_{i-2}^0, \dots, W_1^0))$

for $1 \leq k \leq M_{i-1}$ and $1 \leq j \leq M_i$;

5 associating with each $\alpha_{i,j}$ a probable set of i candidate words;

calculating $\beta_{i,j}$ as $\beta_{i,j} = \max(\alpha_{i,j} \beta_{i+1,k} P(w_{i,j} | W_{i+1}^0, W_{i+2}^0, \dots, W_Q^0))$ for $1 \leq k \leq M_{i+1}$ and

$1 \leq j \leq M_i$; and

associating with each $\beta_{i,j}$ a probable set of Q candidate words,

wherein i identifies one of the at least N subsequences and j identifies one of the at

10 least one subset of candidate words, and

wherein $Q \geq N$, and

wherein the recursive steps of calculating $\beta_{i,j}$ and associating with each $\beta_{i,j}$ are performed for $i=Q, Q-1, \dots, 1$ after the recursive steps of calculating $\alpha_{i,j}$ and associating with each $\alpha_{i,j}$ are performed for $i=1, 2, \dots, Q$.

15

5. The method according to claim 4, further comprising the step of determining the most likely phrase as the probable set of Q candidate words associated with $\max(\beta_{i,j})$ for $1 \leq j \leq M_1$.

6. An interactive method for generating a word trellis from an alphanumeric message entered by a caller using a telephone keypad, comprising in a messaging terminal the steps of:

20

storing a lexical database comprising a plurality of words;

storing a received sequence of key codes that identifies a sequence in which keys on a telephone style keypad are pressed in order to enter the alphanumeric message; and

generating a word trellis from the sequence of key codes, the word trellis comprising

25 at least one subset of candidate words recovered from the lexical database, the step of generating comprising the steps of

determining N subsequences of the received sequence of key codes,

wherein the N subsequences are subsequences of key codes separated within the received sequence of key codes by a predetermined set of key codes,

30 recovering the at least one subset of candidate words from the lexical database based on an input to the lexical database of one of the N subsequences,

identifying one of the N subsequences as an errored subsequence when a null subset is recovered from the lexical database, and

performing keypad error correction using the errored subsequence.

7. The method according to claim 6, wherein the step of performing keypad error correction comprises the steps of:
- generating a new subsequence from the errored subsequence by substituting a
 - 5 different key code for one of the key codes within the errored subsequence; and
 - recovering a subset of candidate words from the lexical database based on the new subsequence, after the step of generating.
8. The method according to claim 6, wherein the step of performing keypad error correction
- 10 comprises the steps of:
- generating a new subsequence from the errored subsequence by deleting one of the key codes within the errored subsequence; and
 - recovering a subset of candidate words from the lexical database based on the new
 - subsequence, after the step of generating.
- 15
9. The method according to claim 6, wherein the step of performing keypad error correction comprises the steps of:
- generating a new subsequence from the errored subsequence by selecting an
 - insertion point adjacent to a key code within the errored subsequence;
 - 20 inserting a key code at the insertion point; and
 - recovering a subset of candidate words from the lexical database based on the new subsequence, after the step of inserting.
10. The method according to claim 6, wherein the step of performing keypad error correction
- 25 comprises the steps of:
- selecting an insertion point between two consecutive key codes within the errored subsequence;
 - splitting the errored subsequence into two new subsequences at the insertion point;
 - and
 - 30 recovering two subsets of candidate words from the lexical database based on the two new subsequences.

11. An interactive method for composing an alphanumeric message by a caller using a telephone keypad, comprising in a messaging terminal the steps of:

- storing a lexical database comprising a plurality of words;
- storing a received sequence of key codes that identifies a sequence in which keys on
- 5 a telephone style keypad are pressed in order to enter the alphanumeric message;
- generating a word trellis from the sequence of key codes, the word trellis comprising at least one subset of candidate words recovered from the lexical database;
- determining a most likely phrase having a maximum combined probability determined from probabilities stored in the lexical database, that comprises a combination of
- 10 one candidate word from each of the at least one subset of candidate words;
- generating a most likely message from the most likely phrase and presenting the most likely message to the caller;
- confirming that the most likely message is the alphanumeric message; and
- editing the most likely message when, in response to the step of confirming, a
- 15 message non-confirmation is received from the caller.

12. The method according to claim 11, wherein the step of editing the most likely message further comprises the steps of:

- determining by caller response an incorrect candidate word from the most likely
- 20 message, wherein the incorrect candidate word is in a first subset of candidate words; and
- presenting other candidate words in the first subset of candidate words that includes the incorrect candidate, one word at time to the caller in decreasing order of unigram probability, until all the candidate words have been presented or a word confirmation is received from the caller.

25

13. The method according to claim 12, wherein the step of editing the most likely message further comprises the steps of:

- presenting all letters represented by each key code in a subsequence of the received sequence of key codes, wherein the subsequence corresponds to the first subset of
- 30 candidate words that includes the incorrect candidate word, and wherein all letters are presented one letter at time to the caller; and
- determining a confirmed letter for each key code by one or more caller responses during the step of presenting all letters.

35 14. The method according to claim 11, wherein the step of editing the most likely message further comprises the step of:

- presenting a next likely message.

15. The method according to claim 11, wherein the step of editing the most likely message further comprises the steps of:

5 first determining by caller response an incorrect candidate word from the most likely message, wherein the incorrect candidate word is in a first subset of candidate words; and presenting other candidate words in the first subset of candidate words that includes the incorrect candidate, one word at time to the caller in decreasing order of unigram probability, until all the candidate words have been presented or a word confirmation is received from the caller.

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16. The method according to claim 15, wherein the step of editing the most likely message further comprises the steps of:

second determining by caller response an incorrect letter of a candidate word when all the candidate words have been presented in the step of presenting the candidate words; and

15

presenting letters associated with a key code corresponding to the incorrect letter determined in the step of first determining, one letter at time to the caller, until all the letters associated with the key code have been presented or a letter confirmation is received from the caller.

20

17. The method according to claim 11, wherein the step of editing the most likely message further comprises the steps of:

prompting the caller to speak an edit command;
recognizing the edit command as one of a predetermined set of edit commands; and
performing the edit command using voice recognition that is governed by a subsequence of the sequence of key codes.

25

18. The method according to claim 17, wherein the step of recognizing the edit command comprises the step of recognizing a word edit command, and wherein the step of performing the edit command further comprises the steps of:

prompting for a vocalized word in response to the word edit command;
recording the vocalized word;
performing voice recognition using a small word recognizer that matches the vocalized word to a candidate word of the at least one subset of candidate words corresponding to the subsequence.

35

19. The method according to claim 18, wherein the step of performing the edit command further comprises the steps of:
- prompting for a sequence of vocalized letters in response to a failure to match the vocalized word to any candidate word of the at least one subset of candidate words
 - 5 corresponding to the subsequence;
 - recording the sequence of vocalized letters; and
 - performing voice recognition using a alphabet recognizer that matches the sequence of vocalized letters to the subsequence of the sequence of keycodes.
- 10 20. The method according to claim 17, wherein the step of recognizing an edit command comprises the step of recognizing a spelling command for a word of the alphanumeric message, and wherein the step of performing the edit command further comprises the steps of:
- prompting for a sequence of vocalized letters in response to the spelling command;
 - 15 recording the sequence of vocalized letters; and
 - performing voice recognition using a alphabet recognizer that matches the sequence of vocalized letters to the subsequence of the sequence of keycodes.
21. The method according to claim 11, wherein in the step of editing the most likely message,
- 20 the editing is performed in response to entries made by an operator.
22. The method according to claim 21, wherein the step of editing the most likely message comprises the steps of:
- determining one or more incorrect candidate words of the most likely message and
 - 25 determining all remaining candidate words as confirmed candidate words of the most likely message when, in response to the step of confirming, a message non-confirmation is received from the caller;
 - presenting a request to the caller to vocalize spoken words of the alphanumeric message that correspond to each of one or more incorrect candidate words, in response to
 - 30 the step of determining one or more incorrect candidate words;
 - recording the spoken words; and
 - presenting to the operator the confirmed candidate words and the spoken words.

23. The method according to claim 22, wherein the step of editing the alphanumeric message further comprises the step of:

generating an operator edited version of the alphanumeric message in response to entries made by the operator that are generated after the step of presenting to the operator
5 candidate words and the spoken words.

24. The method according to claim 23, wherein the operator entries are keyboard entries.

25. The method according to claim 22, wherein the step of editing the alphanumeric message
10 further comprises the steps of:

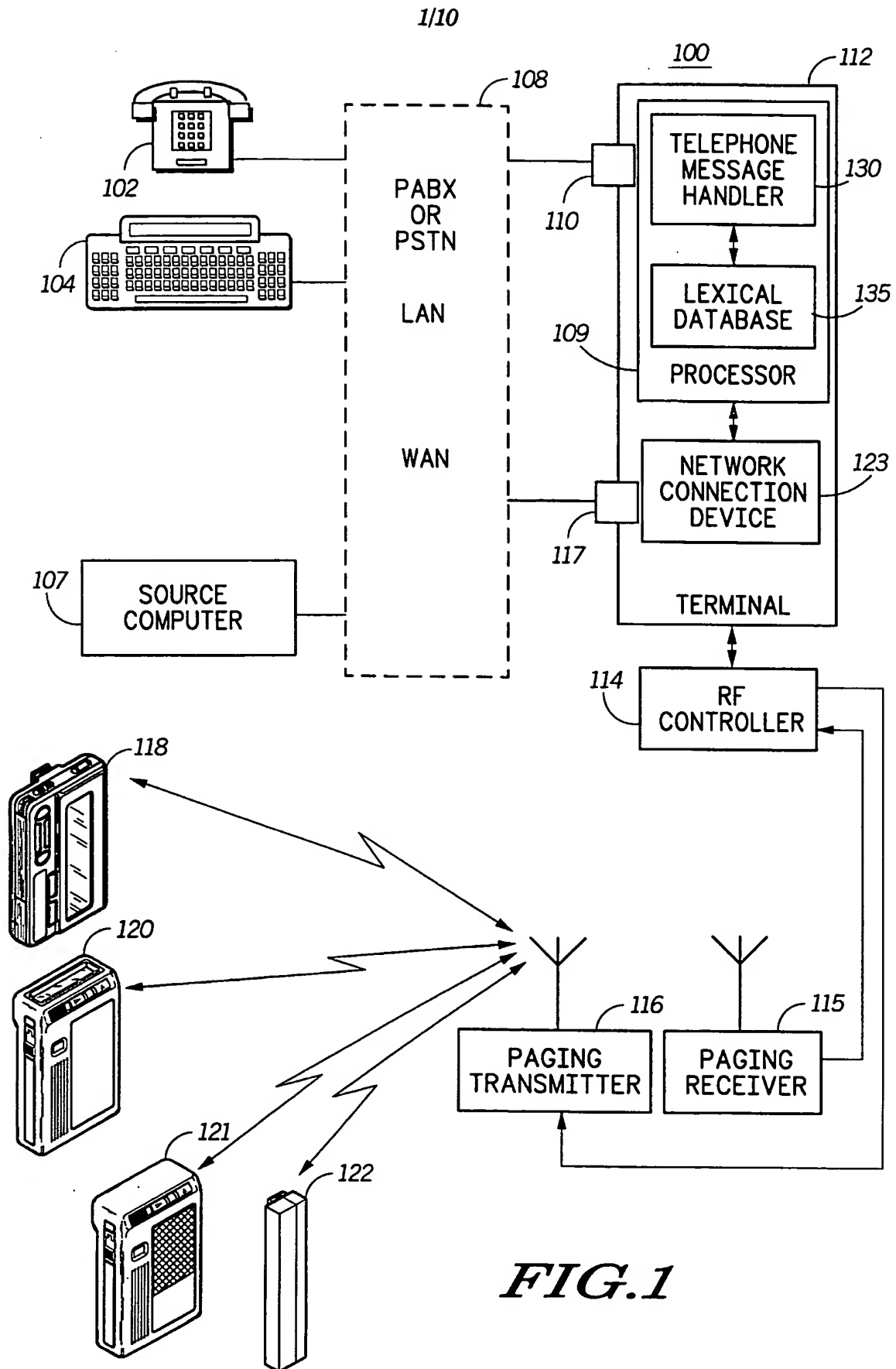
establishing a voice link between the caller and the operator after the step of presenting to the operator the confirmed candidate words and the spoken words; and
generating an operator edited version of the alphanumeric message in response to entries made by the operator after the step of establishing a voice link.

15

26. The method according to claim 25, wherein the voice link is automatically established by the messaging terminal after the step of presenting to the operator the confirmed candidate words and the spoken words.

20 27. The method according to claim 25, wherein the voice link is established by a command generated by the operator.

28. An interactive method for composing an alphanumeric message by a caller using a telephone keypad, comprising in a messaging terminal the steps of:
- storing a lexical database comprising a plurality of words;
 - 5 storing a received sequence of key codes that identifies a sequence in which keys on a telephone style keypad are pressed in order to enter the alphanumeric message;
 - generating a word trellis from the sequence of key codes, the word trellis comprising at least one subset of candidate words recovered from the lexical database;
 - generating the alphanumeric message from the subsets of candidate words,
 - 10 comprising the steps of
 - presenting all candidate words in all subsets of candidate words, wherein all candidate words are presented one candidate word at time from each subset of candidate words to the caller, and one of the steps of
 - confirming a candidate word from a first subset of candidate words by one or
 - 15 more caller responses during the step of presenting, and
 - non-confirming a first subset of candidate words by one or more caller responses during the step of presenting.
29. The method according to claim 28, wherein the step of generating the alphanumeric
- 20 message further comprises the steps of:
 - presenting all letters represented by all key codes in a subsequence of the received sequence of key codes in response to the step of non-confirming, wherein the subsequence corresponds to the first subset of candidate words, and wherein all letters are presented one letter at time to the caller; and
 - 25 determining a confirmed letter for each key code by one or more caller responses during the step of presenting all letters.

**FIG. 1**

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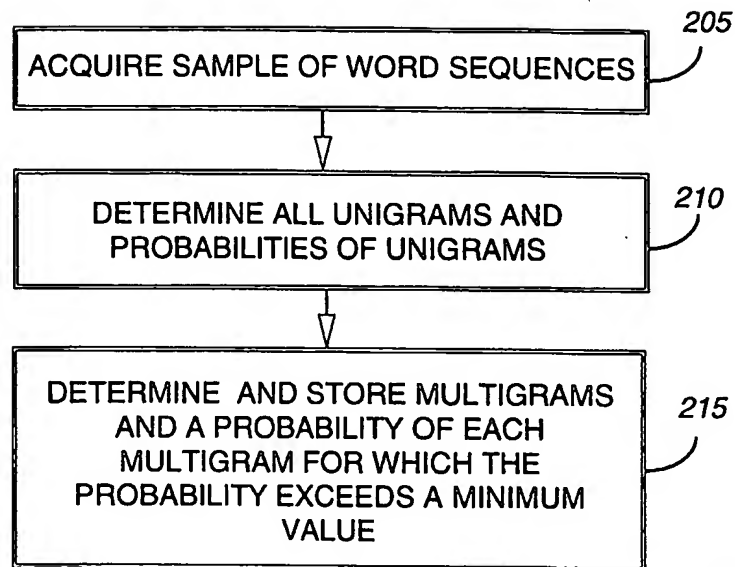


FIG. 2

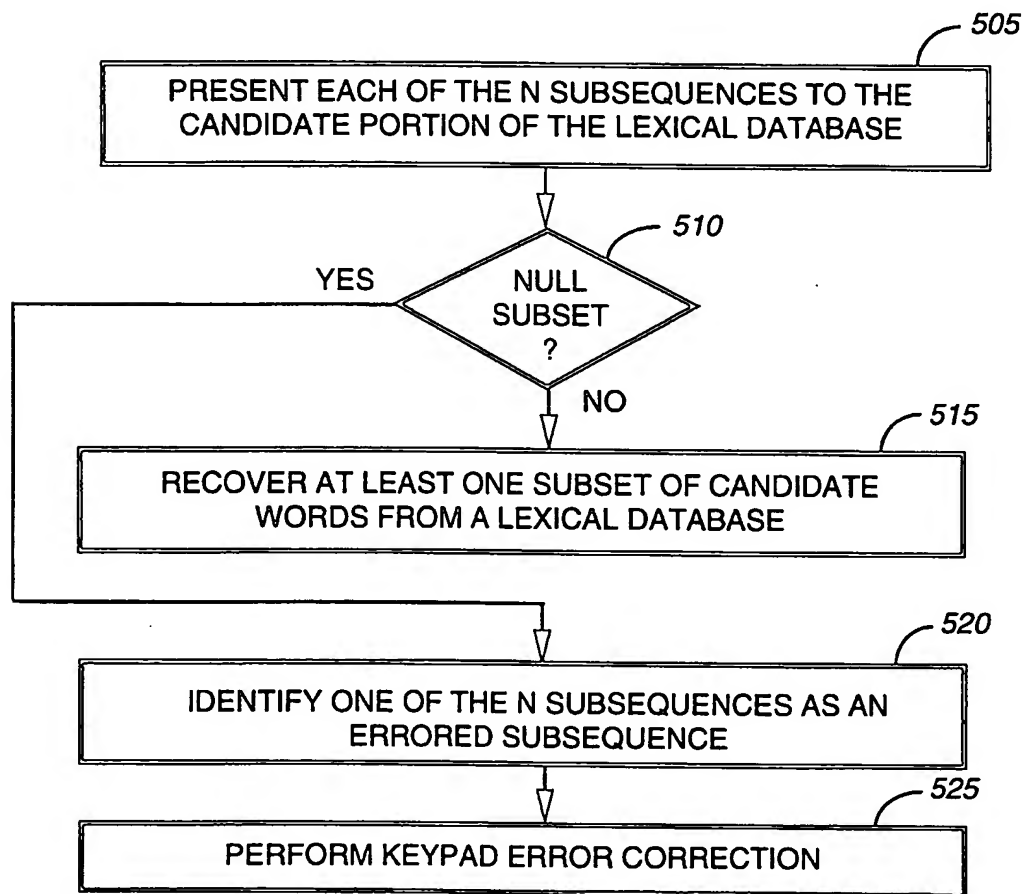
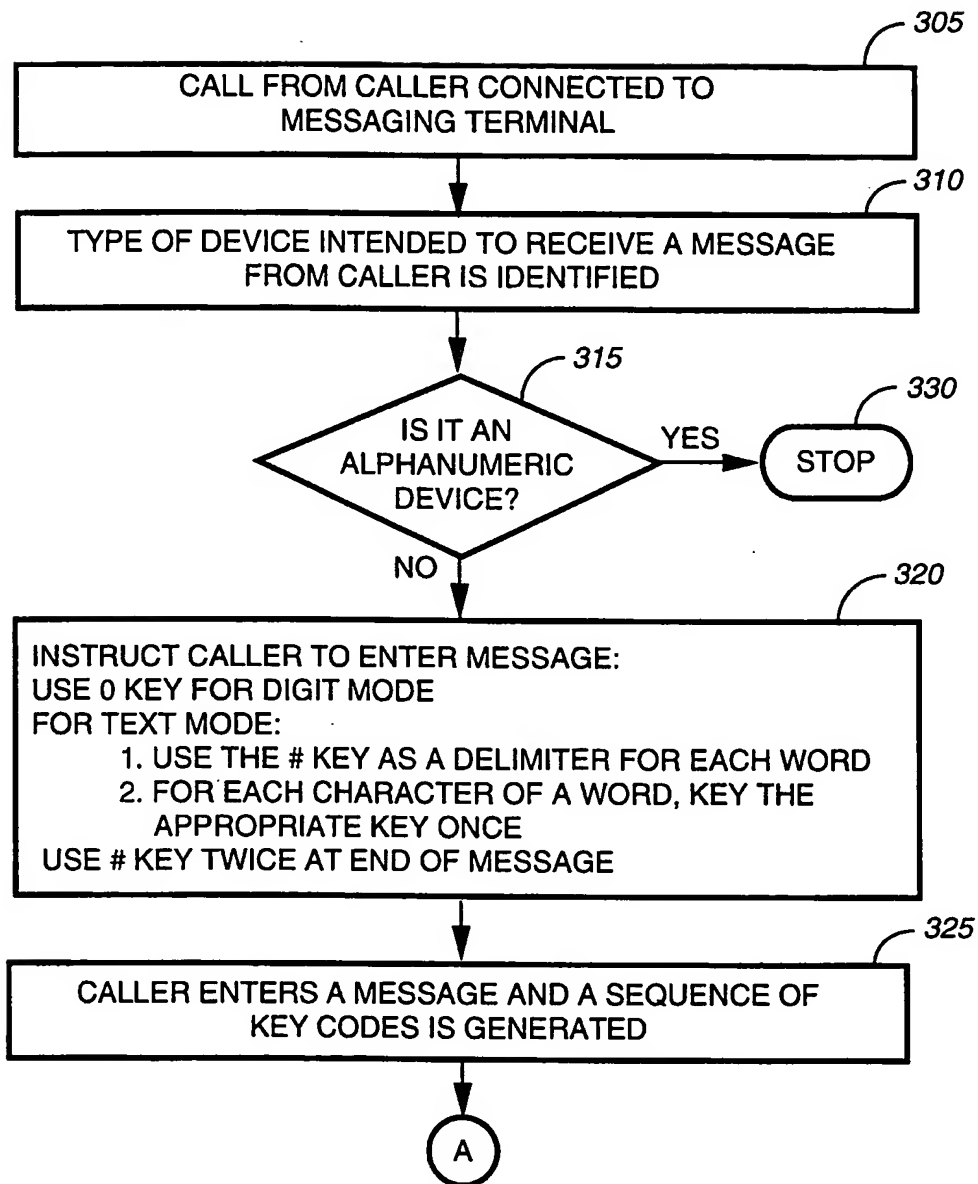


FIG. 5

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**FIG. 3**

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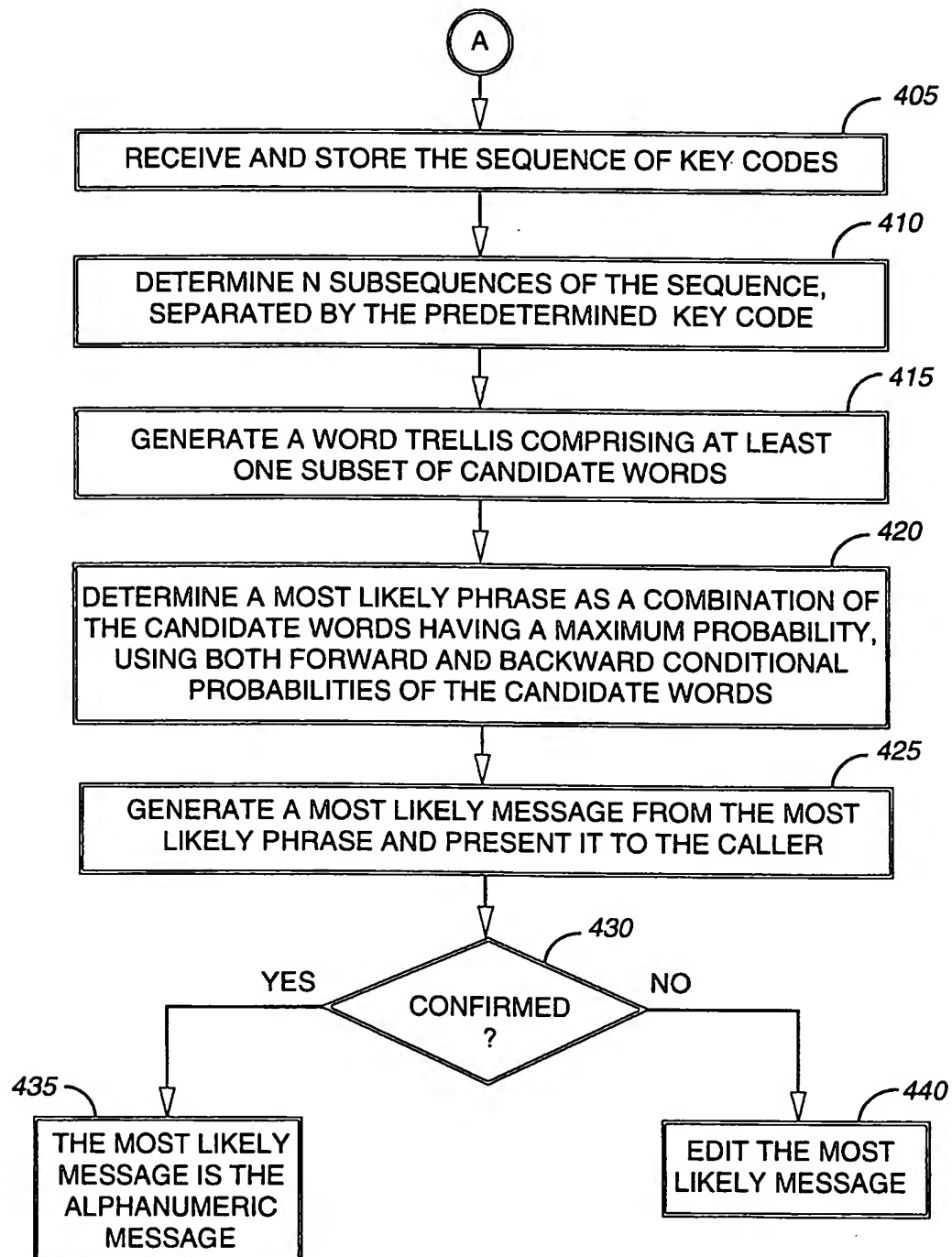


FIG. 4

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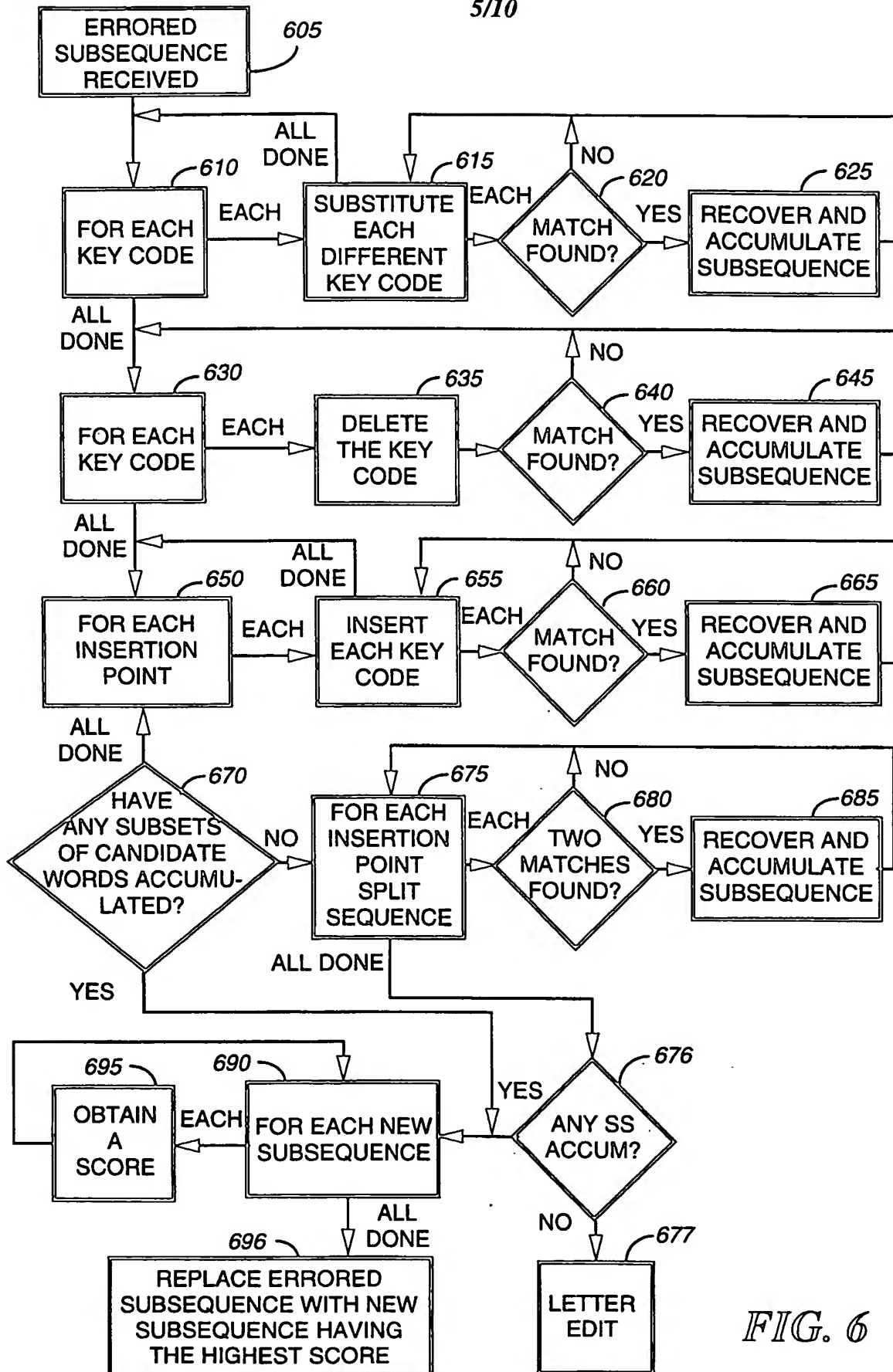


FIG. 6

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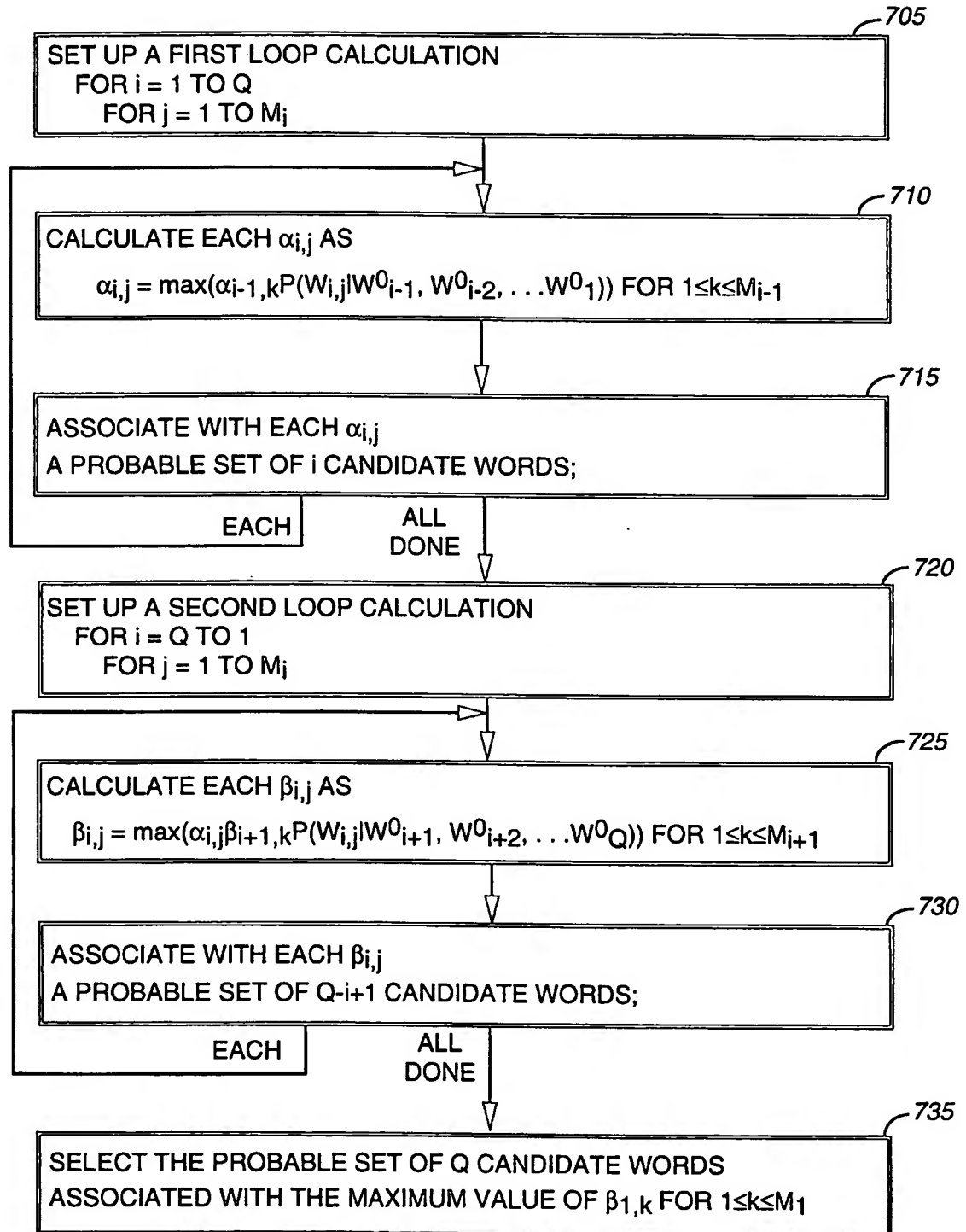


FIG. 7

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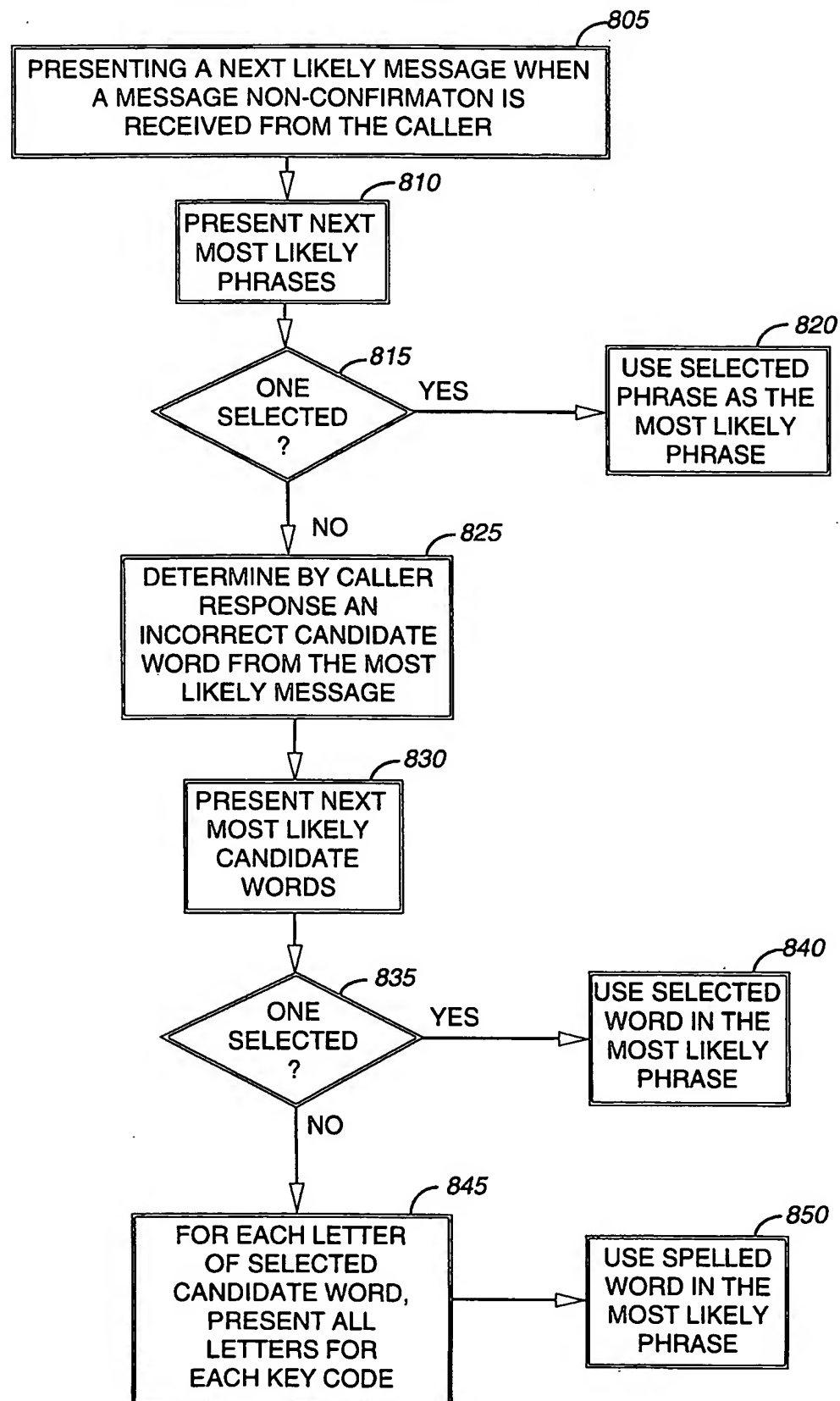


FIG. 8

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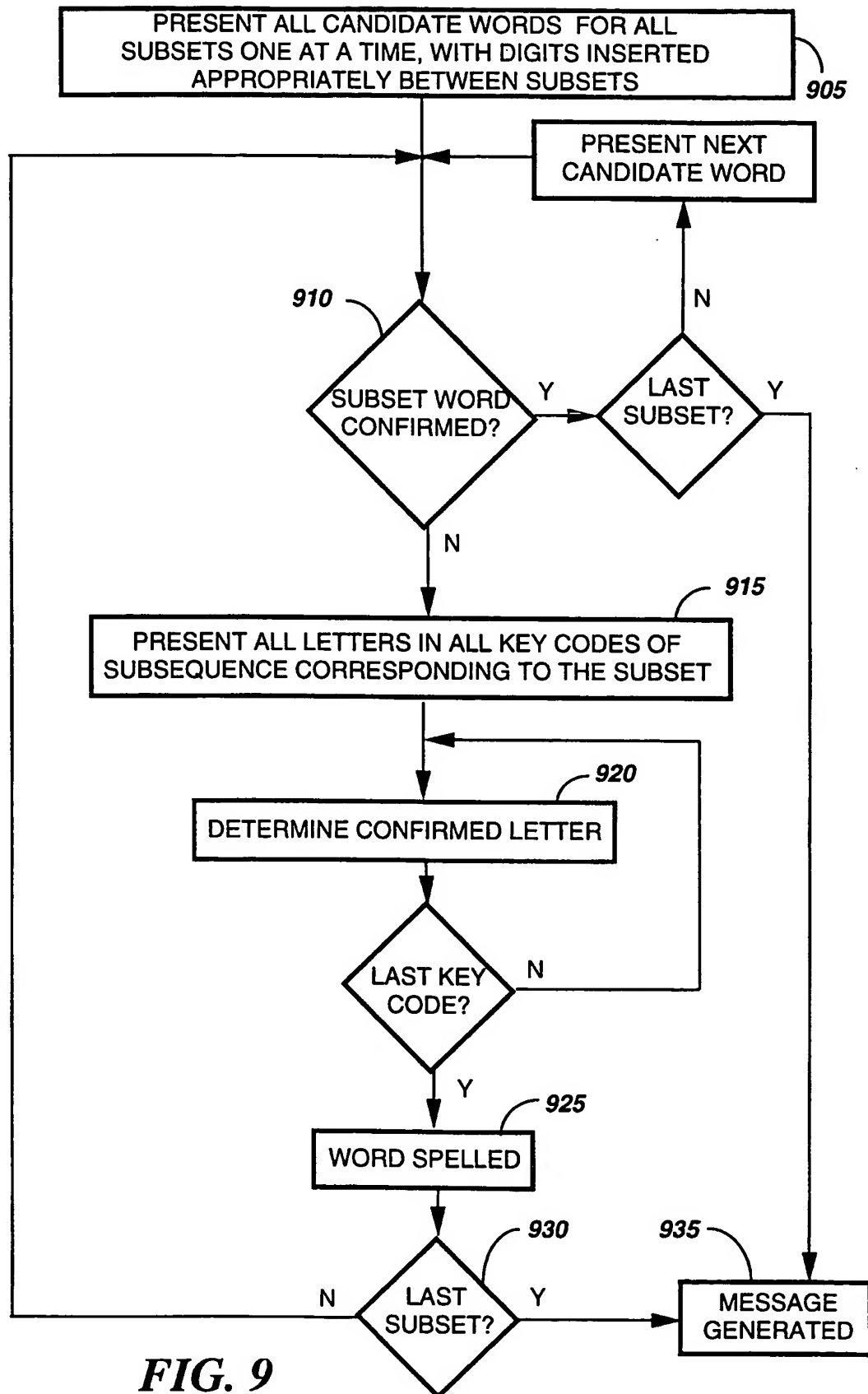


FIG. 9

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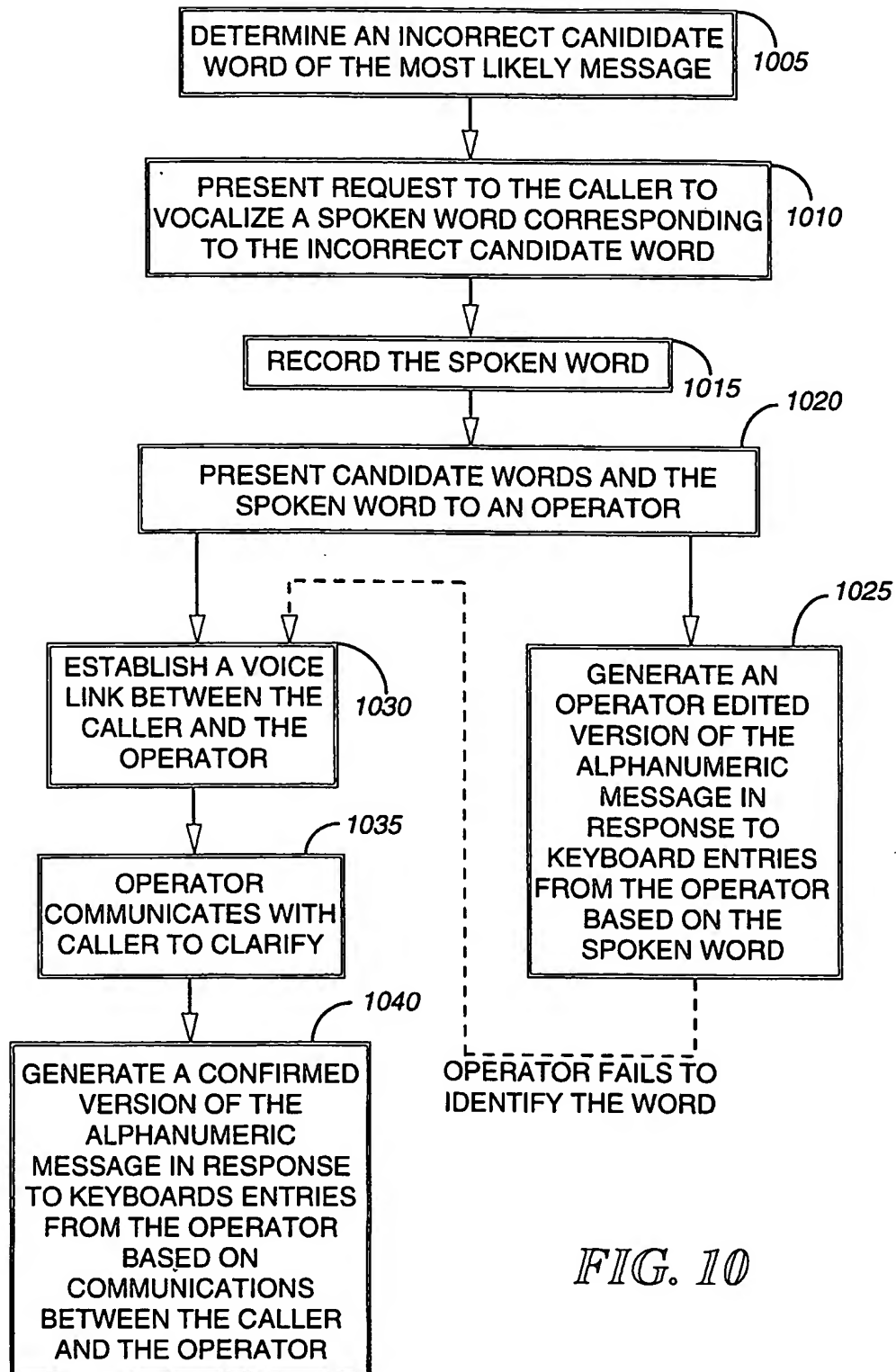


FIG. 10

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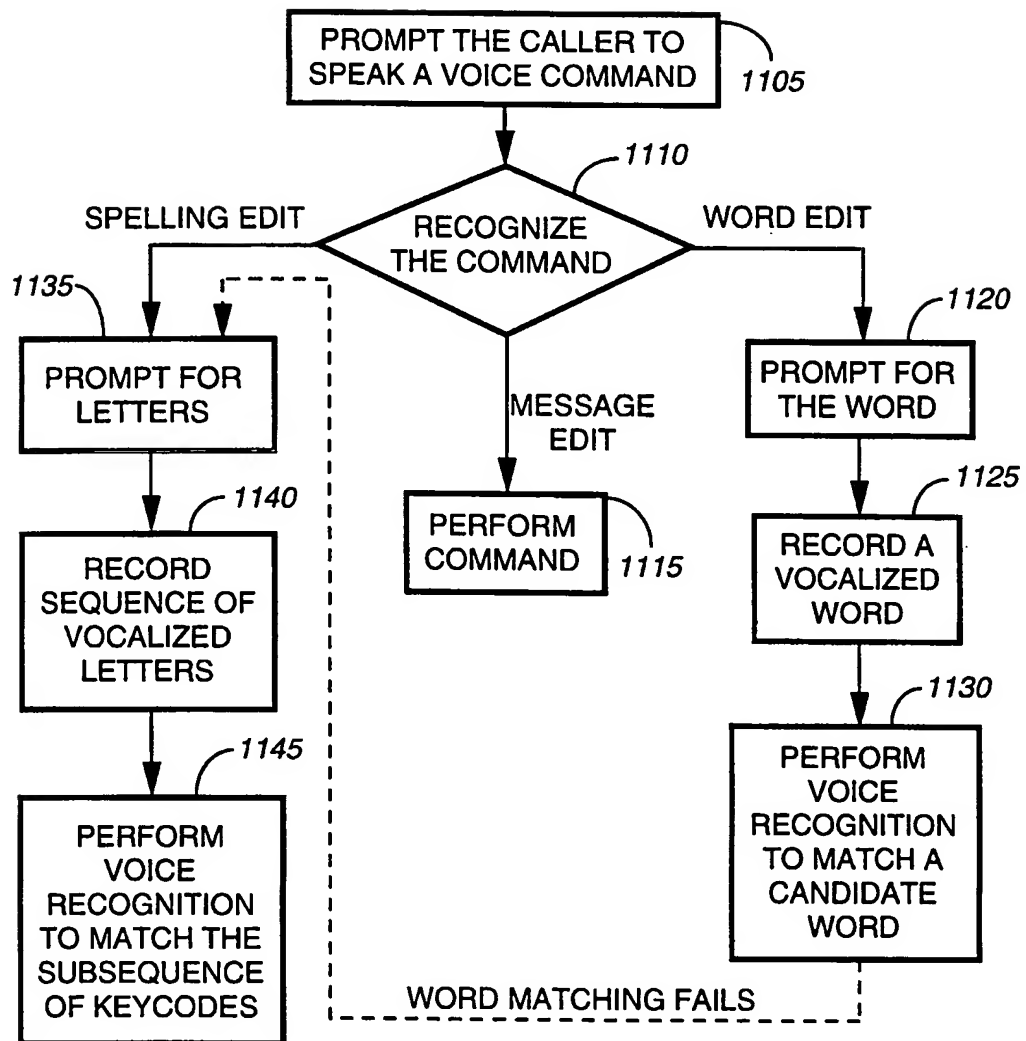


FIG. 11